

NOTE ON THE RELATION BETWEEN THE FREQUENCIES OF COMPLEMENTARY HUES.*

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THERE are available considerable data on the wave-lengths of complementary hues.¹ It appears that such data have always been presented and discussed in terms of wave-length, and not in terms of frequency.² It has been suggested that the curves relating complementary wave-lengths "nearly resemble" (rectangular) "hyperbolæ."³ Inspection of Fig. 1 will show that the approximation to a rectangular hyperbola is not at all close; the alleged likeness is rather far-fetched.

It might reasonably be expected that the relation between frequencies would be simpler than that between wave-lengths. From the point of view of physiologic optics, wave-length can be nothing more than a purely arbitrary reference scale; while it is at least a reasonable hypothesis that some comparatively simple relations may exist between the retinal response and the *frequency* of the stimulus. The author has previously shown that retinal visibility as a function of frequency is simpler than as a function of wave-length.⁴ In this paper it is proposed to show that the relation between the frequencies of complementary hues can be represented in a simple way which is at least suggestive of simple relations between the retinal response and frequency.

The data mentioned above have been replotted, as shown in Fig. 1. A curve has been drawn to represent, as well as may be, these data. From this curve pairs of complementary wave-

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¹ Helmholtz, v. Kries, v. Frey, Koenig, Angier, Trendelenburg and Diterici as quoted in Helmholtz: "Physiol. Optics," 3rd Ed., Vol. 2, p. 107.

² Helmholtz: "Physiol. Optics," 2nd Ed. (1896), pp. 316-319. Helmholtz: "Physiol. Optics," 3rd Ed. Vol. 2, pp. 105-107. Parsons: "Introduction to Study of Color Vision" (Cambridge, 1915) Part I, Sec. II, Chap. III. Rood: "Modern Chromatics" (New York, 1879), p. 175. Köllner: "Störungen des Farbensinnes" (Berlin, 1912), p. 14. Luckiesh: "Color and Its Applications" (New York, 1915), pp. 59 and 75. Grünberg: Sitzb. Ak. Wein, II A, 113, pp. 627-636; 1904.

³ Parsons: "Introduction to Study of Color Vision," p. 35. Grünberg: Sitzb. Ak. Wien, II A, 113, pp. 627-636; 1904.

⁴ *Phy. Rev.* (2) 11, 498, 1918.

FIG. 1.

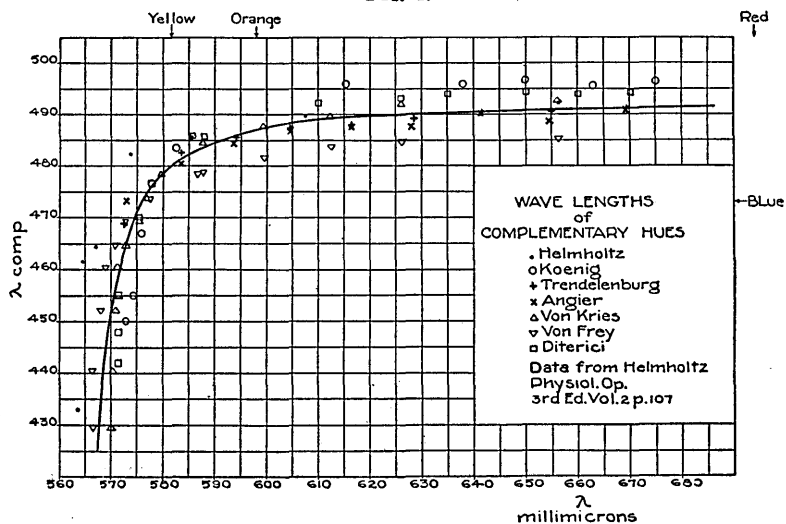
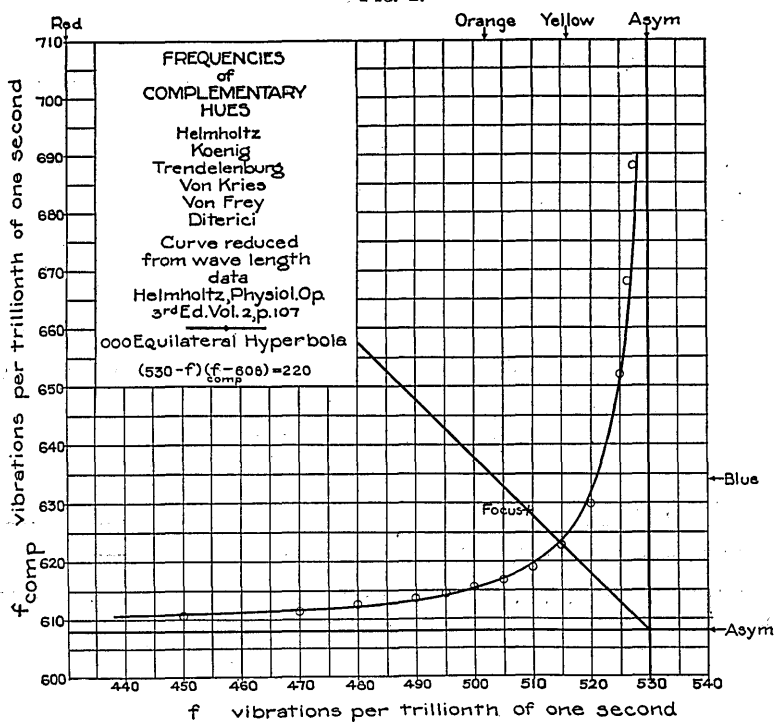


FIG. 2.



lengths have been read. These wave-lengths have been converted into frequencies;⁵ and the relation of frequencies has been plotted (solid curve, Fig. 2). The circles in Fig. 2 have been plotted from the equation of a rectangular hyperbola:

$$(530 - f)(f_{\text{comp}} - 608) = 220$$

That is: the relation between the frequencies of complementary hues can be represented closely by a rectangular hyperbola of which the asymptotes are:

$$530 \text{ and } 608$$

and the focus is:

$$503.2, 628.8$$

There is at present considerable interest in another redetermination of the visibility function. In order that such a determination might yield the largest results, the author would suggest that visibility should be represented as a function of frequency and the visibility of each subject should be correlated with:

1. The frequencies of his spectral complementaries.
2. His sensibility to frequency differences as a function of frequency.
3. The "black-body" spectral energy distribution which he recognizes as gray.⁶
4. The relative intensities of homogeneous complementaries required to be mixed to color match gray specified by the findings under (3) above.

By the correlation of these functions we might reasonably expect to gain a new insight into the various phenomena of color and perhaps elucidate somewhat the nature of the retinal response and its relation to the stimulus.

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$$^5 f \text{ (in vibrations per trillionth of one second)} = \frac{300,000}{\lambda \text{ (in millimicrons)}}$$

⁶ Troland: Trans. I. E. S., 13, pp. 26-27; 1918. Priest: Trans. I. E. S., 13, pp. 75-77; 1918.